



DIE KURZ INFORMATION

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The cover photograph shows the new plant addition at Mühlendorfstraße.

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This copy heralds the edition of a monthly information bulletin by ROHDE & SCHWARZ.

The purpose of the KURZINFORMATION (Short Information Bulletin) is, as its name suggests, to furnish prompt, regular and condensed information on new equipment, practical test assemblies and company events. The information contains detailed instructions on how to modernize old measuring instruments with simple means, gives service reports and do-it-yourself hints for practical measurement accessories.

In the KURZINFORMATION the articles on each instrument are confined to whole sheets. The bulletin can easily be taken apart. Thus the sheets can be filed, like our data sheets, in the proper place of the R & S data sheet folder. Later on, R & S folders will be supplied for the systematic filing of all the sheets.

It is not intended to replace the ROHDE & SCHWARZ-Mitteilungen (house journal), which are issued irregularly, but merely to supplement them with reports in the monthly KURZINFORMATION. In the course of time, our laboratories and test departments have accumulated a wealth of valuable experience which cannot always be immediately utilized for the running production and often is unsuitable for publication in scientific journals. Because of the nature of these special experiences, which we want to make generally available, the KURZINFORMATION is, in particular, meant for users and owners of R & S equipment. On the last but one page you will find business reply cards. Please, send us your requests for subjects and measurement problems you wish to have discussed, let us know what you like about our information bulletin and to what you object. We shall appreciate your hints and criticism since only an exchange of opinions will ensure success.

We trust that this KURZINFORMATION will prove an aid to your measurement problems, providing you, the user of our equipment, with helpful suggestions for your difficult work.

We wish for a friendly reception of the KURZINFORMATION.

J. Rohde

The Frequency and Time Standard Type CAQ

A Portable Frequency and Time Standard of High Accuracy

Constructional Details

For more than 20 years ROHDE & SCHWARZ have been producing instruments for the generation of standard frequency and standard time. During this period R & S have pioneered in the development of this special field of engineering. An example is the latest development in this field, the fully-transistorized Frequency and Time Standard Type CAQ. This instrument replaces the Midget Crystal Clock Type XSZ which was entirely equipped with valves. The Type CAQ takes the place of the Type XSZ also with respect to the technical data. In addition, due consideration has been given, in the development of this new model, to the requirements of modern engineering as well as to various demands which came from the customers and which could not be realized with reasonable means in an instrument equipped with valves.

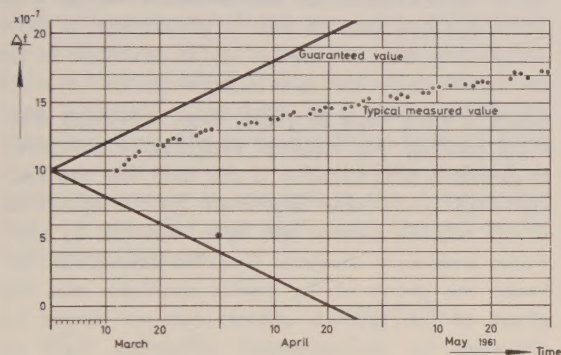
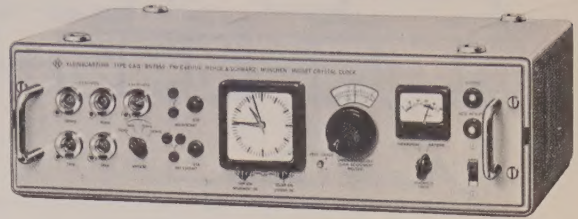


Fig. 1 Typical frequency characteristic after first-time operation of the Frequency and Time Standard

The most important **improvement**, as compared to the earlier model, is the **built-in, automatically chargeable** battery which ensures 15 hours of operation in the case of AC supply failure. This reserve power permits the built-in movement and the seconds contact to be used, besides for frequency checking, also for the active time service and for the "preservation of time". Further improvements are the **seconds contact** which is entirely chatter-free and practically indestructible, the **minute contact** and the **pulse shaper / amplifier**. The latter permits the standard frequencies which, like in the Type XSZ, are emitted as sinusoidal voltages, to be taken additionally as pulse voltages. The pulse shaper / amplifier supplies a very broad frequency spectrum with the selectable pulse repetition frequencies of 100 cps, 1 kc, 10 kc and 100 kc. The new Frequency and Time Standard is, therefore, suitable for the frequency calibration of receivers and generators with frequencies of from 100 cps up to the short-wave range. The **construction of the crystal oscillator** has been made



most carefully. It is housed, together with the buffer amplifier and all frequency-determining components, in a shockproof precision oven. Frequency changes due to environmental influences are thus practically eliminated. The accuracy is essentially influenced only by the individual aging of each oscillator crystal (Fig. 1).

The technical data of the former Midget Crystal Clock and the new Frequency and Time Standard are identical in the most important points; however, the circuit and the construction of the Type CAQ have been based on an entirely new idea. Fig. 2 shows the construction of the instrument. It consists

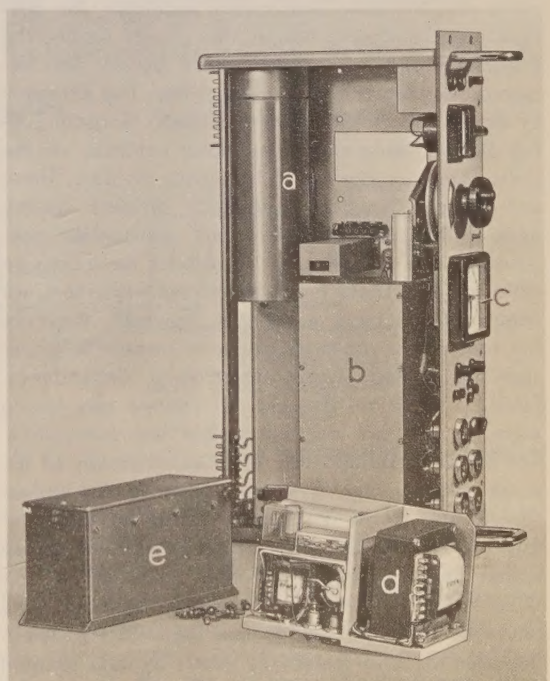


Fig. 2 The components of the Frequency and Time Standard

- (a) The oven with crystal oscillator
- (b) Frequency dividers and output amplifiers
- (c) The movement
- (d) The power supply
- (e) The gas-tight nickel-cadmium battery

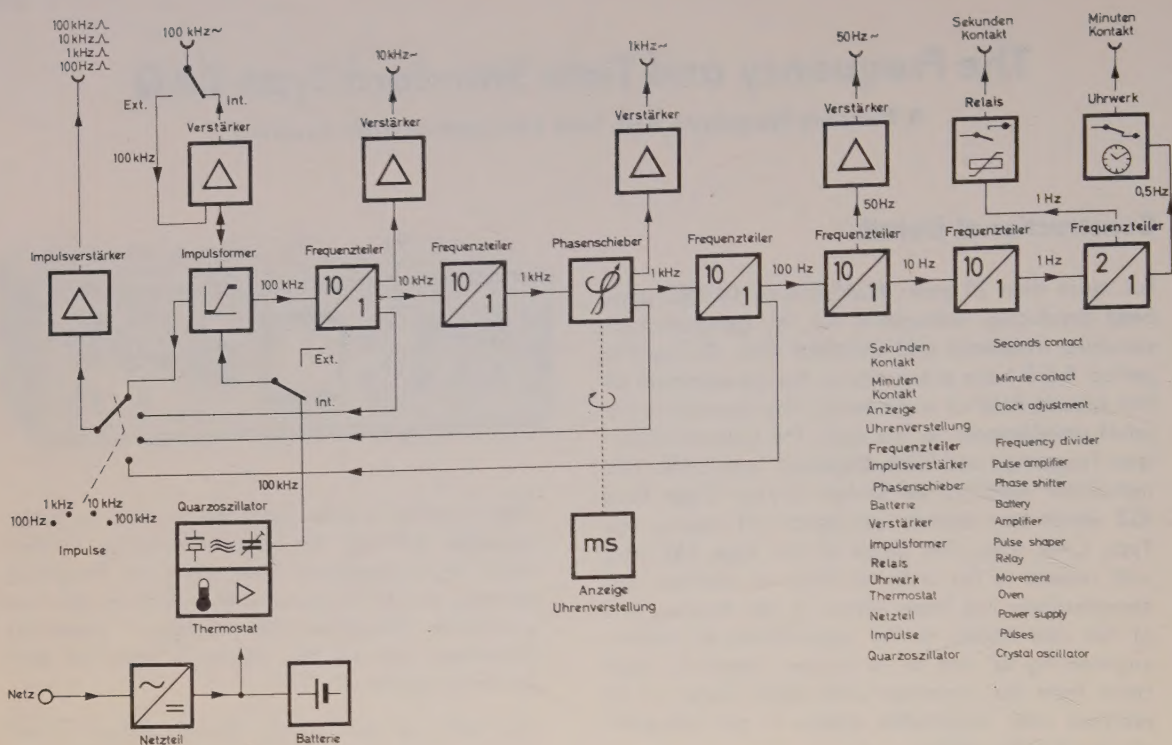


Fig. 3 Block diagram of the Type CAQ

of easily replaceable components which are interconnected either by a few soldering connections or via multipoint connectors. The individual components are: the oven with crystal oscillator, the gas-tight nickel-cadmium battery, the power supply, the movement and the printed circuit boards for frequency divider and output amplifier. The principle of the circuit is shown in the block diagram (see Fig. 3). The 100-kc crystal oscillator controls, via the pulse former, a chain of 5 frequency dividers. These are binary (flip-flop) frequency dividers having exactly the same electrical and mechanical construction and operating with feedback for a division ratio of 10:1. These types of frequency dividers are comparatively more elaborate; however, they are far superior to other circuits with respect to phase stability, voltage and temperature dependence. Since, in addition, they do not contain any tuning elements, they are interchangeable and replaceable. The buffer amplifiers, too, are fundamentally of the same construction; they only differ in the output transformer which is specially tuned for each frequency. With the aid of an **electro-mechanical phase shifter** (goniometer), which is included in the frequency-divider chain, it is possible to adjust the phase of the output frequencies below 10 kc, including seconds and minute contacts, by any amount desired. The adjustment is calibrated in terms of 0.1 msec.

Some technical details are particularly remarkable; for instance, the **seconds contact**, which is wetted with mercury and sealed into a vacuum-tight glass ampulla (Clair relay). Thus it is entirely chatter-free and reaches a life time of more than 10^8 operations,

which is more than 30 years, even with high electrical loading. An essential progress as compared to previous constructions is the fact that the conventional synchronous movement for the operation of the seconds contact has been replaced by electronic frequency dividers. Thus the connection between the phase of the crystal oscillator and the phase of the seconds contact can no longer be disturbed by environmental influences, such as shock, vibration, temperature, etc., which has as a result the high switching accuracy of the seconds contact. Another considerable improvement is the **drive of the movement** by a step motor at intervals of one second. This motor consumes less electrical power than the conventional 50-cps synchronous motor, which is of advantage especially in battery operation. In addition, the stepwise drive necessarily results in a good switching accuracy of the minute contact actuated by the movement, without elaborate mechanical means being necessary.

Finally, mention shall be made of the **particular function of the power supply**. The power supply supplies, via a voltage regulator, the load- and AC supply-independent voltage for the instrument and for battery charging in buffer operation. The uniqueness of the power supply is that the rated value of the regulated voltage has been made dependent on the temperature of the battery. The charging voltage thus adapts itself largely to the temperature-dependent source impedance and the temperature-dependent EMF of the gas-tight nickel-cadmium battery. This circuit prevents over-charging of the battery otherwise unavoidable in case of high ambient temperature. Also the change of the rated volt-

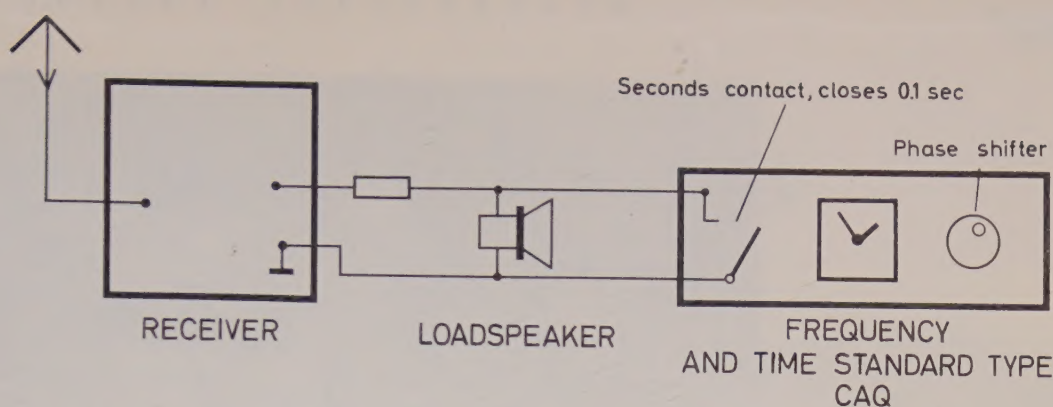


Fig. 4 Acoustic time comparison

age due to aging of components thus has a lower influence on the battery charging. The advantages of this power supply are saving of battery power, longer life and higher reliability.

Applications

The many possibilities of application of the Frequency and Time Standard can best be seen from some practical examples:

The Type CAQ finds its most interesting application in a considerable number of **observatories** which work independently of one another and are located at distances of up to 2000 km from each other. Here a time standard is required which makes the time information available in a form suitable for tape recording. The error should be below 1 msec during an observation time of 24 hours. In addition, great importance is attached to the demand that the time standard also emit exact frequencies for calibration purposes.

amplitudes of the three repetition frequencies are clearly offset. A pulse code, which is well suited for tape recording, is generated by additionally using the seconds and the minute contact.

In order to meet the accuracy requirement, however, the instrument must be daily corrected by a small amount **against radio time signals**. With good receiving conditions, this requires practically no special facilities and, due to the exactly calibrated phase shifter, it does not cause any difficulties even in the case of unskilled personnel. It is just necessary to connect the seconds contact of the Frequency and Time Standard, which closes every second for 0.1 sec, to the loudspeaker output of the local receiver, the reception thus also being cut off every second for 0.1 sec (see Fig. 4). Using the phase shifter, the phase of the seconds contact can now easily be so adjusted that the short-circuiting of the loudspeaker coincides with the arrival of the time signal, whereby the latter becomes inaudible. Where the receiving

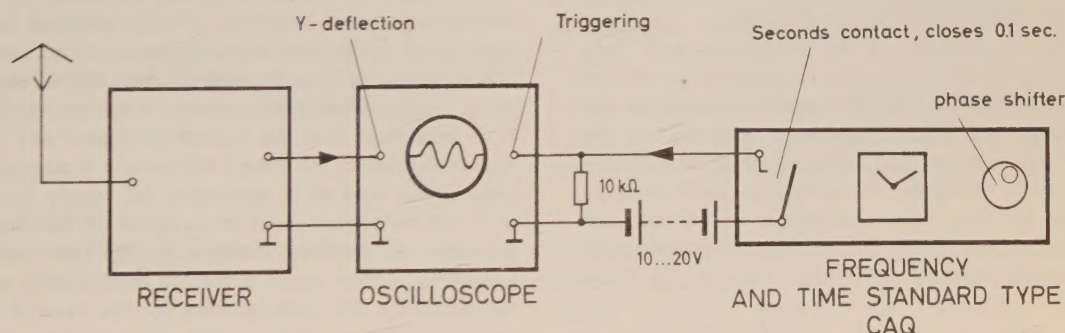
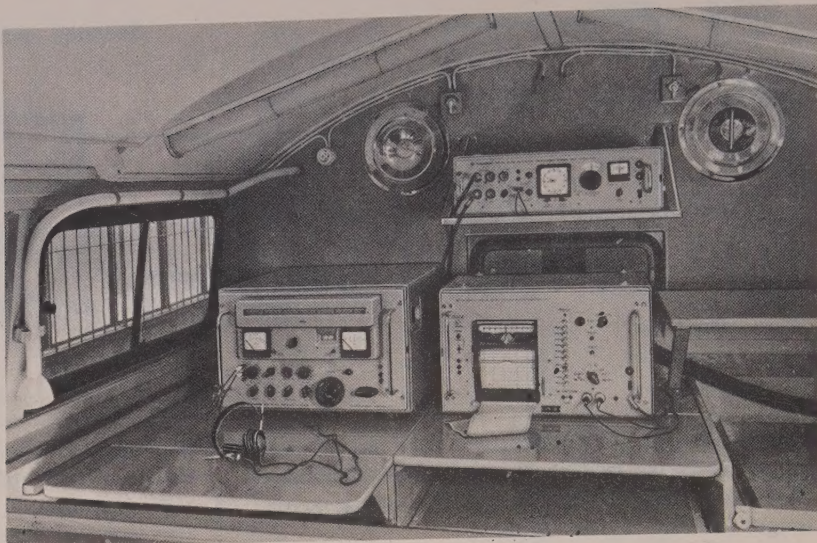


Fig. 5 Oscillographic time comparison

Strictly speaking, a large R&S Standard Time System Type CAA would be suitable for this purpose, since it easily meets all the requirements mentioned. The use of these systems, however, is ruled out because of their weight which would be too high for mobile operation. Since a considerable number of units is required, the problem could be solved using a special model of the new Frequency and Time Standard. The construction of the special model is such that, instead of the pulse output selectable for different frequencies, one common output is provided which supplies pulses of 10 cps, 100 cps and 1000 cps simultaneously at the same connector. The

conditions are good, this very simple method permits the Frequency and Time Standard to be synchronized with the radio time signal to better than 0.2 msec. If, however, the receiving conditions are unfavourable, similar accuracy can be reached with the oscillographic time-signal comparison method (see Fig. 5). For this purpose, the time base of a commercial cathode-ray oscilloscope is triggered with the seconds contact, the low-frequency time signal from the receiver is applied to the vertical deflection plates. Due to its characteristic form, the beginning of the time signal can easily be distinguished from noise voltages and can then be synchroniz-

Fig. 6 Frequency and Time Standard in a test van



ed in time with the beginning of the line—i.e. beginning of the contact-making of the seconds relay—by using the phase shifter. The time error of the Frequency and Time Standard, found if the time-signal measurement is made at regular intervals and the indication of the phase shifter calibrated in terms of 0.1 msec is recorded, can be duly considered in the evaluation of the tape by linear interpolation. The relative frequency error of the Frequency and Time Standard can also be found easily from the time-signal measurements. Two time measurements made with an interval of one day in between are sufficient for the determination of the frequency with an error of max. ± 2 parts in 10^9 . If necessary, the frequency can also be readjusted by means of an externally accessible trimmer. Thus all conditions made for this application are fulfilled.

Another application of the Frequency and Time Standard, which is not less interesting, is in the planned **modernization of a small astronomical observatory**. Here the problem is to equip one of the telescopes with an hour drive which is as accurate as possible. Moreover, the pendulum clock used up to now for time determinations is to be replaced by a better instrument. The existing polarized jumping-seconds-hand slave clocks are to be used again.

In this case, too, a large Standard Time System Type CAA manufactured by R & S would be preferable. For economical reasons, however, the problem is solved with a Frequency and Time Standard adjusted to sidereal time, which means a considerable improvement of the previous state. The modifications required on the telescope are insignificant. It is only necessary to replace the speed-regulated DC motor for the hour drive by a 50-cps synchronous motor. This synchronous motor receives its operating voltage from the R & S Power Amplifier Type ATN which, in turn, is controlled by the 50-cps output of the Frequency and Time Standard. All output frequencies, including seconds and minute contact, are sidereal frequencies, since the oscillator crystal of the Frequency and Time Standard used

in this case is adjusted to 100 kc sidereal. For this reason, no special sidereal-time gearing is necessary. The versatility of the Frequency and Time Standard is shown by its adaptation to the existing slave clocks. For this purpose, it is necessary to modify the circuit of the Frequency and Time Standard so that the seconds contact operates with 0.5 cps instead of with 1 cps. This modification can be carried out by changing the soldering connection of only one single wire.

Another typical example of application is the use of the Frequency and Time Standard Type CAQ for the **control of our Frequency Synthesizers** Types XUA, XUB, XUD. These instruments are provided with built-in crystal oscillators the quality of which is sufficient for normal purposes. However, if the controlling crystal oscillator is to be checked by a time-signal comparison as to its frequency accuracy, a Frequency and Time Standard Type CAQ is required as standard-frequency source. In this connection, it is important that the crystal oscillator and the time indication of the Type CAQ remain in operation even in the case of a temporary AC supply failure or if the instrument must be switched off for transportation to another working place. The control frequency is then again available immediately with full accuracy; the warm-up time for the oven of the crystal oscillator, which would otherwise be necessary, is omitted. If the frequencies below 100 kc and the time indication are not required for some time, they can be switched off, which increases the reserve power in case of AC supply failure to 100 hours.

The possibilities of application of the instrument are by no means exhausted with these examples. The Frequency and Time Standard is, for instance, also suited as a chronometer for ships; as a time standard for clock-manufacturing works, physical and geodetical institutes; for the control of slave-clock systems; as a frequency standard in the electronic industry, etc. But the few practical applications give already an idea of how the special qualities of the Frequency and Time Standard Type CAQ can be used to advantage.

L. Mooser

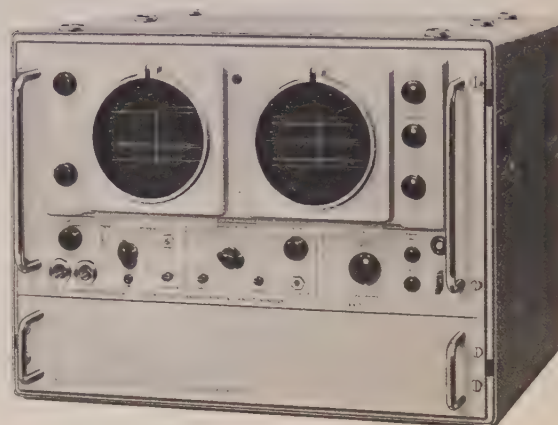
<u>Order Number</u>	► BN 7850
Outputs	Adaptable HF sockets 4/13, built to German standard DIN 47284
sinusoidal	100 kc, 10 kc, 1 kc, 50 cps 2 v each, source impedance 600 Ω, spurious modulation down more than 60 db
positive pulses	100 kc, 10 kc, 1 kc, 100 cps, switch-selected; 3 v _{pp} , pulse duration less than 3 μsec; source impedance 60 Ω; spurious modulation down more than 60 db
Stability	
mean daily frequency drift	less than 5 parts in 10 ⁸ /day after 3 days of operation less than 2 parts in 10 ⁸ /day after 60 days of operation
effect of battery voltage between charged and discharged .	less than 1 part in 10 ⁸
effect of ambient temperature variation	between +15°C and +30°C: less than 5 parts in 10 ⁸ between 0°C and +40°C: less than 1.5 parts in 10 ⁷
Frequency adjustment	
trimmer range	in thermostat: 1 part in 10 ⁵ outside of thermostat: 1 part in 10 ⁵ } 2 parts in 10 ⁵
setting accuracy	2 parts in 10 ⁸

Thermostat	
warm-up period for frequency error of less than 1 part in 10^6 ..	3 hours
permissible ambient temperature ..	0 to +40°C
check	on panel meter
Time indication	
movement	jumping seconds hand and 12-hour dial opens for 0.1 sec; spread in start of contact opening less than ± 0.2 msec;
seconds contact	max. contact loading: 24 v, 300 ma
minute contact	opens for 1 sec; spread in start of contact opening less than ± 3 msec;
	max. contact loading: 24 v, 300 ma
Time adjustment	
movement alone	hour and minute hands mechanically adjusted by knurled knob, seconds hand electrically adjusted by interrupter
movement plus contacts	by phase shifter; adjustment accuracy better than 0.1 msec
Power supply	
	in fixed installation by a-c supply or local battery, during transit or power failure by built-in storage batteries charged by the power section; power section and storage batteries individually removable
a-c supply	115/125/220/235 v, 40 to 400 cps, 20 va with internal battery charged, max. 50 va with internal battery discharged
internal battery	gas-tight DEAC cells 12 v, 3.5 ah; check on panel meter
external battery	11 to 16 v, approx. 350 ma; permissible only with internal battery and power section disconnected
charging time of internal battery	4 hours for half charge
	20 hours for full charge
operating time with internal battery (at room temperature)	12 hours with complete instrument switched on, 140 hours with only thermostat and crystal oscillator switched on
Transistors	
	51 x AF 101, 11 x OC 604, 4 x OC 604 sp
	2 x OC 470, 1 x OC 30, 1 x CTP 1512
Dimensions (W x H x D)	
	540 x 166 x 378 mm (R&S Standard Cabinet 5
Weight	
	complete with cabinet: 20 kg
	battery alone: 2.5 kg
	power section alone: 2.5 kg
	cabinet alone: 6 kg
Recommended accessories	
(to be ordered as extras)	HF connectors 4/13 DIN 47284;
	R&S Stock No. FS 413/11;
	patch cord 50 cm: BN 90516/50
	100 cm: BN 90516/100
	screw-in sockets for other connectors: see data sheet 902000

Improvements on the VF-RF Level Oscilloscope Type OHF

a. Sweep Starting Point in FRAME Switch Position

With instruments of the type series E 468/1/... and E 468/2/... an apparent shift of the starting point of the time bases of both cathode-ray tubes towards the right takes place in the TIME-BASE VF-RF switch positions FRAME as compared to the positions LINE. This shift is caused by the shape of the leading edge of the unblanking pulse, the leading edge partly being formed by the beginning of the time-base sawtooth. With the instruments of a later date this effect is avoided almost entirely by additional clipping of the unblanking pulse in the grid circuit of valve 26 (E 88 CC) by means of diode G1 15 (OA 81), R 253 (WF 160 k/0,25) and R 254 (WF 100 k/0,25), see Fig. 1. The small group of circuit elements can easily be incorporated in the instruments of the two above-mentioned series.



VF-RF Level Oscilloscope Type OHF

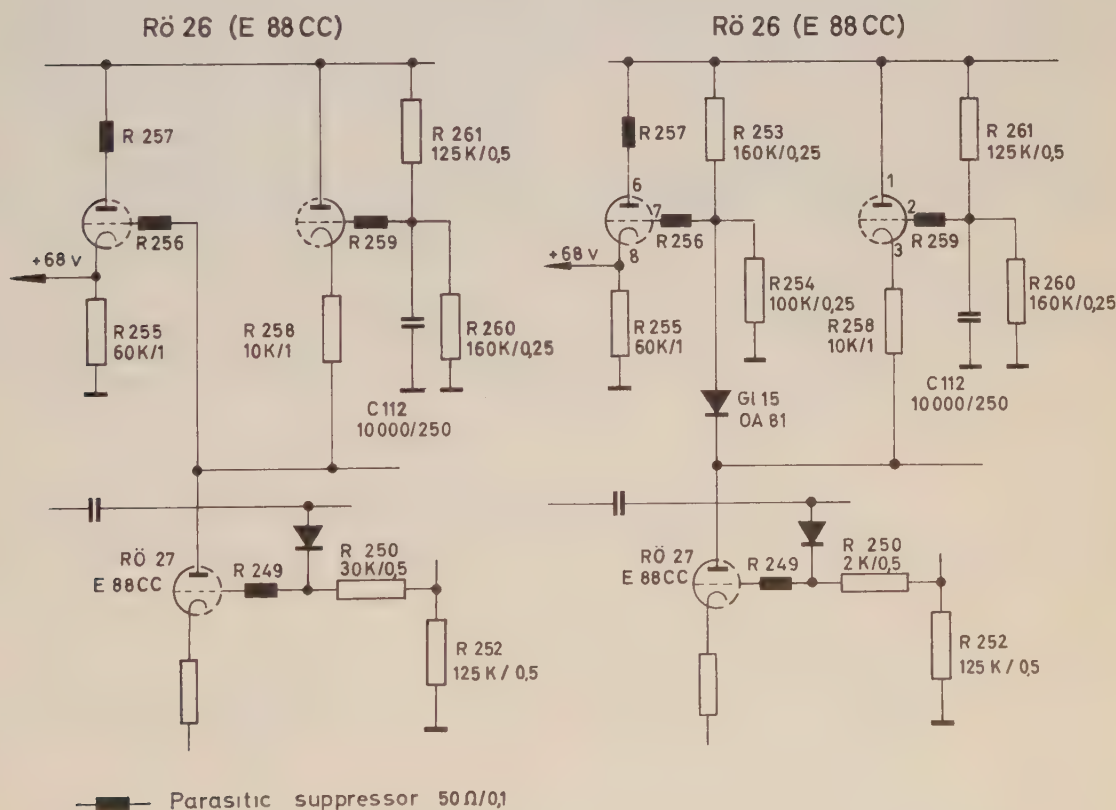


Fig. 1 Circuit Diagram

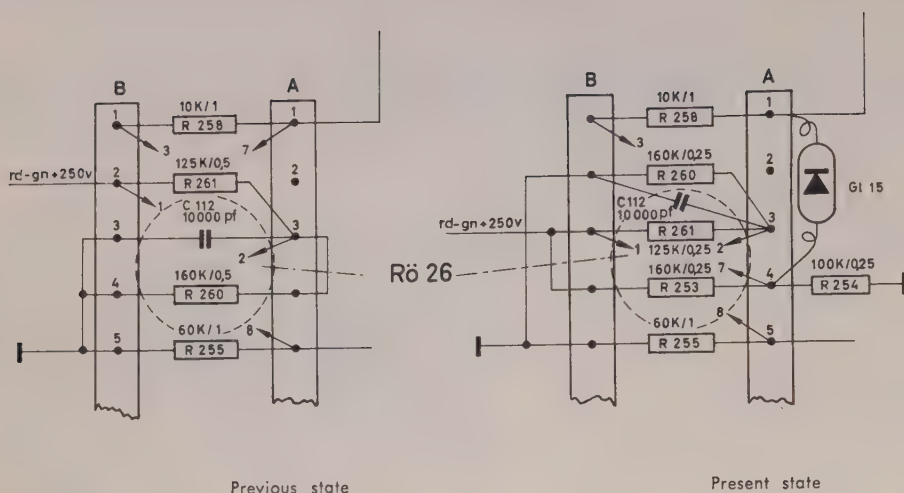


Fig. 2 Wiring Diagram

The arrows point to the contact springs of the valve socket.
Parasitic suppressor resistors are not shown.

Mounting Instructions (Fig. 2)

1. Remove resistors R 261 (125 k/0,5) and R 260 (160 k/0,25), capacitor C 112 (10,000/250) and the connection A3-A4. It is also possible to leave R 260 as R 253.
2. Change chassis connections according to diagram; now, B 2 and B 5 are connected to chassis.
3. Remove the 250-v line (red/green) from B 2 and connect it to B 3 and B 4. Make a connection from B 3 to the anode of valve 26, pin 1.
4. Remove the parasitic suppressor R 256 from A 1, and connect it to A 4.
5. Solder Gl 15, R 260, C 112, possibly R 253, R 261 and R 254 according to wiring diagram.

b. Blanking of the Retrace

The trailing edge of the unblanking pulse lags somewhat behind the end of the time base. Thus the first portion of the retrace becomes visible on the screen over a length of about 18 mm. With the new instruments, this visible portion of the retrace has been reduced to about 4 mm by decreasing the time constant of the grid circuit of valve R 27. Resistor R 250 with 30 k/0,5 is to be replaced by another one with 2 k/0,5. This change can be made according to Fig. 1 on the instruments E 468/1/... , E 468/2/... and partly also on the instruments E 468/3/...

c. Linearity of Sweep in FRAME Position

The linearity of the sweep in FRAME position is within $\pm 5\%$ and meets the standard requirements. It can be improved to about $\pm 2\%$ by decreasing the screen-grid feedback of valve 29 (EF 800) with low frequencies. This can be reached by increasing the capacitance C 126 from 0.1 μf to 4 μf /350 v. For the stabilization of the Miller integrator, however, it is necessary to increase the capacitance C 125 across the suppressor-grid resistor from 10,000 pf/250 v to 100,000 pf/250 v. The replacement of these capacitors can easily be made according to Fig. 3.

No adjustment work is necessary for all the procedures described.

H. W. Schulz

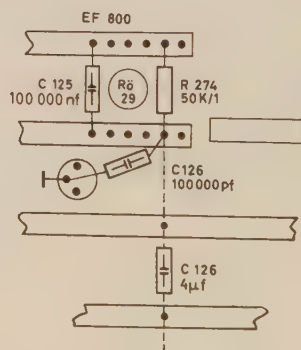


Fig. 3 Recommended Connection of Capacitors C 125 (100 nf) and C 126 (4 μf).

Solid line: previous state
Dashed line: present state

R & S Instruments for AF and RF Measurements

Physical or technical problems are solved by theoretical and empirical methods, but reasonable use of these two methods is warranted only by utmost simplification. In electronic measurements, simplification of the work is possible both with precision instruments and thorough theoretical knowledge. For example, from the many quantities that could be measured, four basic quantities, which are independent of one another, are sufficient to describe all the phenomena appearing in physics and in electrodynamics. These four quantities have been established arbitrarily: Current I (amp), voltage E (v), length l (cm) and time t (sec) have proved useful for engineering problems and can easily be measured (Mie's system). All the other quantities as, e. g., capacitance C (farad) = $\frac{I \times t}{E}$

$\left[\frac{\text{amp} \times \text{sec}}{\text{v}} \right]$, magnetic induction B (gauss) = $10^{-8} \times \frac{E \times t}{l^2} \left[\frac{\text{v} \times \text{sec}}{\text{cm}^2} \right]$, force F (kgf) = $\frac{1}{10.2} \times \frac{E \times I \times t}{l}$
 $\left[\frac{\text{v} \times \text{amp} \times \text{sec}}{\text{cm}} \right]$, etc., can be derived therefrom.

Statements on physical conditions in electrical engineering can only be obtained indirectly using special technical setups which make the electronic processes perceptible for our sense organs. No matter how these test setups are arranged, as a result a certain electrical power must be available for optical or acoustic indication (pointer-type meter, cathode-ray tube, headphones).

The electron tube was the cause that electrical measurements, and particularly RF measurements, developed into pure voltage measurements. The fact that current measurements are largely avoided does not mean a contradiction to the above demand for the knowledge of the four basic quantities, because, according to Ohm's law, the current is the quotient of the voltage divided by the resistance. For example, measurements on slotted lines are nearly always made in the form of voltage measurements. The current measurement, according to the four basic quantities, is here obviously omitted for describing the electrical condition on the line, because this current obtains from a voltage measurement and from the value of the characteristic impedance of the line together with its termination.

Especially in the field of high frequencies it becomes obvious that practically only voltage measurements are possible. Even the measurement of power, which originally is defined as the product of current and voltage, can be reduced to voltage measurements without any knowledge of the current.

For this reason, it is logical that Rohde & Schwarz build, for scientific and technical work, a great variety of instruments for voltage measurements. Since many of the items under test do not have voltage sources of their own, great importance has been attached to the development of such sources, which results in the great number of signal generators offered.

A work which with R & S has become a tradition is the building of standard frequency and time systems. The development of precision instruments for measurement on resistors, inductors and capacitors is also far advanced. — Since the general trend towards automation also exists in measurements, automatic measuring instruments have been created which considerably shorten tiresome conventional measurements by carrying them out automatically.

The following survey of the Rohde & Schwarz measuring instruments is at the same time a survey of scientific and technical fields of research.

The range limits given in the following always refer to the entire group of instruments mentioned. Individual instruments cover only a smaller range.

A. Instruments and Accessories for the Measurement of Voltages and Waveforms

BN 1 . . .

1 Aperiodic Voltmeters

BN 10 . . . to BN 12 . . ., Type U . . .

11 different voltmeters with and without preamplification are available for the voltages of from 10 μ v to 50 kv and the frequency ranges 0 cps, and 10 cps to 1600 Mc.

2 Selective Voltmeters, Receivers

BN 15 . . ., Types U . . ., E . . ., H . . .

Nearly 25 instruments for very versatile applications permit voltage measurements between 0.3 μ v and 20 v in a frequency range of from 10 kc to 2700 Mc.

A great number of field-strength measuring systems and field-strength measuring instruments, some of which are easily portable, are provided for measurements in the near-zone and far-zone fields. Seven high-quality receivers of from 0.5 to 900 Mc are available for radio-communication service. Some of them can be used for measurements in radioastronomy if parametric amplifiers are connected ahead of them. Receivers provided with special supplements permit accurate measurements of noise voltages. In the frequency range of from 30 to 400 Mc a selective voltmeter with automatic frequency tracking, the Type USWV, is available, the tracking speed being higher than 10 Mc/msec.

3 Instruments for Measuring the Waveform, Including Modulation Meters

A DC recorder of from 0.01 to 300 v with a pen speed of 250 msec is available for slow voltage variations. For higher frequencies, oscilloscopes are suitable which are offered for the range 0 to 20 Mc and for the TV Bands I, III, IV. The Picture Transmitter Test Assembly for the monitoring of TV transmitters comprises a considerable number of instruments, such as generators, voltmeters, oscilloscopes and sweep signal generators.

The modulation meters are a special group among the instruments for checking the time behaviour of AC voltages: test demodulators for the TV Bands I, III and IV/V, frequency deviation meters for the frequency ranges 20 to 300 Mc and the TV Bands I, III and IV/V, and a phase meter. The analyzers listed in section E2 also belong indirectly to the setups for measuring waveforms.

4 Auxiliary Units: Attenuation Boxes, Directional Couplers

11 different types of directional couplers, balanced and unbalanced attenuation boxes permit the voltages under test to be accurately reduced with attenuations of from 0 to 130 db in the frequency range 0 to 12,400 Mc. In the frequency range below 10 to 50 Mc, a delay line for a time delay up to 1.105 μ sec, adjustable in steps of 5 nsec, is available.

B. Oscillators, Signal Generators, Modulators and Frequency Standards

Mainly BN 4 . . .

1 Oscillators and Signal Generators for the Generation of Sinusoidal Voltages

BN 40 . . ., BN 41 . . ., Type S . . .

About 30 instruments covering beat-frequency oscillators, transmission measuring sets, RC oscillators, calibration oscillators, signal generators, power signal generators, TV signal generators, Carcinotron signal generators and sweep signal generators meet all requirements occurring in practice. The types of modulation are in each case adapted to the most important applications of the signal generators. In the frequency range of from 2 cps to 11,400 Mc output voltages of from 0.05 μ v to 30 v with powers of up to 20 w can be obtained.

2 Generators for Producing Non-sinusoidal Voltages, and Modulators

BN 41 . . ., BN 42 . . ., Type S . . .

Two noise generators of from 30 cps to 1000 Mc, test pattern generators, precision blanking & sync signal mixers, UHF and waveguide modulators complete our line of voltage sources.

3 Frequency Standards of High Stability

BN 444 . . ., Type X . . .

Two decade frequency synthesizers with a frequency accuracy of 2 parts in 10^8 cover a frequency range of from 0 to 30 Mc. Frequencies up to 18,000 Mc with crystal-controlled accuracy can be generated using a times-ten frequency multiplier and harmonic generators. Frequency standards of 100 kc and 1 Mc have an accuracy of 10^{-9} to 10^{-10} . Standard time systems and midget crystal clocks can also be used as frequency standards. They are listed once more in detail in section F.

4 Auxiliary Instruments: Amplifiers

BN 13 . . . , BN 16 . . . , Type A . . .

Four different amplifiers of from 2 cps to 300 Mc with an output power of up to 50 w and one peak limiter 40 to 15,000 cps raise the power level up to 110 db.

C. Instruments for Power Measurements

BN 2 . . . , Types N . . . , U . . .

Six different power meters, such as wattmeters, microwave power meters and insertion-head type power meters with matching indicator have proved useful in the frequency range of from 0 to 4500 Mc for powers from 20 mw to 10 kw.

D. Instruments and Auxiliary Units for Measurements of Impedances and on 4-terminal Networks

1 Instruments for Resistance, Inductance and Capacitance Measurements on Components

15 instruments with the

frequency ranges of from 0 cps to 100 Mc

have been developed for measuring ohmic resistances, capacitances, inductances, impedances, dissipation factors and circuit Q's.

It is possible to measure

resistances of from 0.01Ω to $100 M\Omega$

capacitances of from 10^{-4} pf to $5000 \mu f$

inductances of from $0.1 \mu h$ to $1000 h$

dissipation factors of $\tan \delta = 2$ parts in 10^4 to 1 and

Q's of coils of $Q = 1$ to 600.

Among these instruments there is a limit bridge for testing large quantities of resistors, capacitors and coils. Moreover, this group of instruments comprises a high-voltage tester, which can determine the dielectric strength and the insulation resistance of components, etc. The high-grade automatic test bridge permits production tests on heavy-current capacitors. The dissipation factor and the capacitance of the capacitor are measured at operating voltage.

2 2- and 4-terminal Networks

can be measured in the AF range by a test rig combining signal generators, standard attenuators and voltmeters. In the frequency range of 0.5 to 1200 Mc this measurement is considerably simplified by using R & S **sweep signal generators** which display two separate response curves at the same time. If they are used in conjunction with the Selektomat featuring automatic frequency tracking (Type USWV) the 4-terminal networks may offer a high attenuation without impairing the reading accuracy since even with a voltage of $10 \mu v$ at the 4-terminal network output the electron beam is fully deflected on the screen of the sweep signal generator.

The **Z-g Diagrams** Types ZDD and ZDU provide in the VHF and UHF region, i. e. in the frequency range of 30 to 2400 Mc, for time-saving measurement of impedances of 1.2 to 3000Ω with respect to magnitude and phase or resistive and reactive components. Transfer constant, voltage ratio, reflection coefficient, etc. can be directly read on charts. A special **transistor adapter** enables the dynamic behaviour of transistors to be measured. The **Impulse Reflectometer** Type ZUPI covering the range 47 to 223 Mc is used for the measurement of irregularities and the location of reflections on transmission lines and cables.

The line of instruments for 4-terminal network measurements includes also

3 Standing-wave Detectors

BN 3 . . . , Type L . . .

A large number of standing-wave detectors (80 to 12,400 Mc), reflectometers (10 to 4200 Mc) and waveguide directional couplers (3600 to 12,400 Mc) permit measurements up to the SHF range.

4 Auxiliary Units for Impedance and 4-terminal Network Measurements

are adjustable shorts, impedance transformers, broadband baluns, matching pads, resistance, capacitance and inductance standards and load resistors.

Decade

resistors 0.1Ω to $120 k\Omega$,

capacitors 100 pf to $1.11 \mu f$ and

inductors 0 to $10 h$

are as indispensable as are fixed standard and load resistors of 50, 60 and 75Ω which are available in 6 different type series from 0 to 12,400 Mc for loads of 1 w to 10 kw.

Last but not least, another basic quantity which can be electrically measured is the time or its reciprocal value.

E. Frequency and Sound Meters

BN 43 . . . to BN 48 . . .

1 Frequency Meters

BN 43 . . . , BN 44 . . . , BN 74 . . . , Types W . . . , X . . . , F . . .

Fifteen resonance and heterodyne frequency meters as well as frequency indicators cover a frequency range of 10 cps to 12,400 Mc. Furthermore, a crystal-controlled decade frequency measuring system for precision frequency measurements (10 cps to 1000 Mc) is available. Mixer and harmonic generators extend this frequency range beyond 12,000 Mc.

2 Wave Analyzers

BN 46 . . . , BN 48 . . . , Type F . . .

A direct-reading distortion meter, the AF wave analyzer and the AF spectrograph were designed for the AF range of 30 to 20,000 cps. Special selective octave filters are used to suppress unwanted pulses. An auxiliary unit for sound recordings is the tape-splice interference suppressor. The four frequency-deviation meters listed in section A.3 (Instruments for Measuring the Waveform) permit the frequency modulation to be measured.

3 Sound Meters

BN 45 . . . , Type E . . .

A number of instruments including handy battery-operated instruments serve to measure vibration and sound level.

F. Standard Time Systems

BN 78 . . . , Type C . . .

Standard time systems with an accuracy of 1 part in 10^8 to 1 part in 10^{10} were designed for application in scientific institutes, astronomical observatories, etc. Recorders, all-wave receivers for oscillographic time comparison, sidereal time converters, programme contactors for time signals, relay units for slave clocks, and servo motors are combined to make up the large and small time systems. A small portable midsize crystal clock with a rate of 1 part in 10^8 per day is used to advantage in mobile service, in particular, in geodesy.

G. Auxiliary Units

The auxiliary units include high-stability power supplies for high and low voltages, balanced general-purpose transformers, impedance transformers, broadband baluns, matching pads, test antennae, also of the parabolic type, for field-strength measurements.

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